Status and Prospect of Phytosanitary Irradiation in China

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Outline

• Research
  – Minimum Dose for Regulated Pests
    • Fruit insects
    • Other pests
  – Fruits Tolerance to Radiation
  – Trends in Research

• Standards and Facilities

• Challenges and Prospects
Reseaches on fruit insects

• **Aim:** Alternative to Methyl Bromide Fumigation

• **Fruit insects** → Minimum dose for PI
  - Fruit Flies (6 species)
  - Bores (2 species)
  - External feeders: mealybugs and mites (5 species)

• **Quality Tests** → Tolerant dose
  - Varieties: mango, papaya, guava, bell fruit, pome fruit...
  - Testing items
    - sensory characteristics
    - physicochemical indexes: sugar, acid, vitamin C...
# Published data on fruit flies

<table>
<thead>
<tr>
<th>Insects</th>
<th>Instars</th>
<th>objectives</th>
<th>Dmin (Gy)</th>
<th>Efficacy</th>
<th>year</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Bactrocera tryoni</em></td>
<td>Larvae</td>
<td>Preventing adult emergence</td>
<td>60</td>
<td>ED&lt;sub&gt;99.9913&lt;/sub&gt;</td>
<td>1995</td>
</tr>
<tr>
<td></td>
<td>Pupae</td>
<td>Preventing F&lt;sub&gt;1&lt;/sub&gt; egg hatch</td>
<td>75</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td><em>B. citri</em></td>
<td>Pupae</td>
<td>Preventing F&lt;sub&gt;1&lt;/sub&gt; egg hatch</td>
<td>90</td>
<td>100%</td>
<td>1992</td>
</tr>
<tr>
<td><em>B. dosalis</em></td>
<td>L&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Preventing adult emergence</td>
<td>87.7</td>
<td>Probit 9</td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td>L&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Confirmatory test</td>
<td>116</td>
<td>ED&lt;sub&gt;99.9963&lt;/sub&gt;</td>
<td>2010</td>
</tr>
<tr>
<td><em>B. papayae</em></td>
<td>L&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Preventing adult emergence</td>
<td>106.8</td>
<td>Probit 9</td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td>L&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Confirmatory test</td>
<td>161</td>
<td>ED&lt;sub&gt;99.9957&lt;/sub&gt;</td>
<td>2010</td>
</tr>
<tr>
<td><em>B. correcta</em></td>
<td>L&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Preventing adult emergence</td>
<td>125.5</td>
<td>Probit 9</td>
<td>2012</td>
</tr>
<tr>
<td></td>
<td>L&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Confirmatory test</td>
<td>113</td>
<td>ED&lt;sub&gt;99.9957&lt;/sub&gt;</td>
<td>2012</td>
</tr>
<tr>
<td><em>B. ocipitalis</em></td>
<td>L&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Preventing adult emergence</td>
<td>150</td>
<td>100%</td>
<td>1989</td>
</tr>
<tr>
<td></td>
<td>L&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Preventing adult emergence</td>
<td>107.1</td>
<td>Probit 9</td>
<td>2011</td>
</tr>
</tbody>
</table>

**Notes:**
- **ED** stands for Effective Dose, which is a measure of the absorbed dose of radiation that is required to achieve a specific effect.
- **Probit** is a statistical method used in the analysis of dose-response relationships.
- The numbers in parentheses represent the range of values.
Oriental Fruit Flies

- **Bactrocera dorsalis**
  - Dose-response tests: L1, L2, L3 in guava fruits
  - L3 is the most tolerant to radiation
  - ED$_{99.9968} = 87.7(73.8-98.3)$Gy
  - Confirmatory test in 2013: 100~116Gy, ED:99.9970%
## Published data on other fruit pests

<table>
<thead>
<tr>
<th>Insects</th>
<th>Instars</th>
<th>Objectives</th>
<th>Dmin (Gy)</th>
<th>Efficacy</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Conopomorpha sinensis</em></td>
<td>Mature pupae</td>
<td>Preventing adult emergence</td>
<td>250</td>
<td>100%</td>
<td>1995</td>
</tr>
<tr>
<td></td>
<td>Larvae</td>
<td></td>
<td>250</td>
<td>ED&lt;sub&gt;99.5&lt;/sub&gt;</td>
<td>1998</td>
</tr>
<tr>
<td><em>Dysmicoccus neobrevipes</em></td>
<td>Female with egg</td>
<td>Preventing adult emergence</td>
<td>150</td>
<td>100%</td>
<td>2011</td>
</tr>
<tr>
<td><em>Pseudococcus jackbeardsleyi</em></td>
<td>Mature female</td>
<td>Preventing emergence of F&lt;sub&gt;1&lt;/sub&gt; 2&lt;sup&gt;nd&lt;/sup&gt; nymphs</td>
<td>133.7 (117.2~168)</td>
<td>Probit 9</td>
<td>2013</td>
</tr>
<tr>
<td><em>Carposina sasakii</em></td>
<td>Egg (larvae)</td>
<td>Preventing adult emergence</td>
<td>161.4 (135.5~216)</td>
<td>Probit 9</td>
<td>2013</td>
</tr>
</tbody>
</table>
# Peach Fruit moth

preventing adults emergence from larvae

<table>
<thead>
<tr>
<th>Larval instars</th>
<th>Dose (Gy) lead 100% mortality</th>
<th>Probit analysis</th>
<th>Heterogeneity</th>
<th>ED(_{99}) (Gy)</th>
<th>ED(_{99.9968}) (Gy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L(_1)</td>
<td>100</td>
<td></td>
<td>1.84</td>
<td>123.0</td>
<td>167.6</td>
</tr>
<tr>
<td>L(_2)</td>
<td>120</td>
<td></td>
<td>0.27</td>
<td>117.4</td>
<td>155.1</td>
</tr>
<tr>
<td>L(_3)</td>
<td>140</td>
<td></td>
<td>0.73</td>
<td>128.0</td>
<td>164.8</td>
</tr>
<tr>
<td>L(_4)</td>
<td>140</td>
<td></td>
<td>3.60</td>
<td>134.0</td>
<td>177.9</td>
</tr>
<tr>
<td>L(_5)</td>
<td>&gt;140</td>
<td></td>
<td>0.47</td>
<td>157.5</td>
<td>208.6</td>
</tr>
</tbody>
</table>
Research on other pests

• Forest Insects (imported logs)
  – Beetles
  – Bark beetles

• Stored Product Pests
  – Insects:
    • Mung Beans Weevil, *Callosobruchus chinensis*
    • Maize Weevil, *Sitophilus zeamais*
    • Khapra Beetle, *Trogoderma granarum*
  – Fungus:
    • Dwarf bunt of wheat, *Tilletia controversa*
### Sterile dose of forest insects (Coleoptera)

<table>
<thead>
<tr>
<th>Forest insects</th>
<th>Instars</th>
<th>Sterile dose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anoplophora glabripennis</strong></td>
<td>Larvae</td>
<td>60Gy: prevent pupation</td>
</tr>
<tr>
<td></td>
<td>Larvae</td>
<td>50Gy: prevent adult emergence</td>
</tr>
<tr>
<td></td>
<td>Pupa</td>
<td>60Gy: prevent $F_1$ larvae</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>$\varphi$ 60Gy, $\delta$ 80Gy: prevent $F_1$ larvae</td>
</tr>
<tr>
<td><strong>Xylotrechus rusticus</strong></td>
<td>Larvae</td>
<td>50Gy: prevent pupation</td>
</tr>
<tr>
<td></td>
<td>Pupa</td>
<td>80Gy: prevent $F_1$ larvae</td>
</tr>
<tr>
<td><strong>Monochamus alternatus</strong></td>
<td>larvae</td>
<td>61.4Gy: prevent adult emergence</td>
</tr>
<tr>
<td></td>
<td>Pupa</td>
<td>120Gy: prevent $F_1$ larvae</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>$\leq 6d$: 120Gy; $\geq 7d$: 160Gy</td>
</tr>
<tr>
<td><strong>Monochamus sutor</strong></td>
<td>Larvae</td>
<td>60Gy: prevent adult emergence</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>160Gy: Prevent of $F_1$ larva emergence</td>
</tr>
<tr>
<td><strong>Ips subelongatus</strong></td>
<td>Larva, Pupa</td>
<td>80Gy: prevent adult emergence</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>80Gy: Prevent $F_1$ adult emergence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>140Gy: Prevent $F_1$ pupae emergence</td>
</tr>
<tr>
<td><strong>Ips sexdentatus</strong></td>
<td>Adult</td>
<td>140Gy: Prevent $F_1$ pupae emergence</td>
</tr>
</tbody>
</table>
Beetles & Bark Beetles: 9MeV X-ray

- **Asian Longhorn Beetle: Anoplophora glabripennis**
  - Mature Larvae: 60Gy prevent pupation
  - Pupa: Sterile dose less than 100Gy
  - Adult: 100Gy prevention egg-laying
Trends in research

• Radio-resistance: mixed to separately
• Test: dose-response to confirmatory tests
• Efficacy: 100% to statistic level (probit 9)
• Data: probit analysis as normal method
• Detection/monitor dose in tests

• Standardization and Internationalization
Phytosanitary Irradiation Standards

- **Established (national) Standards**
  - GB14891.5-1997: *Hygienic standard* for irradiated fresh fruits and vegetables
  - GB/T21659-2008: *Guidelines for the use of Irradiation as a phytosanitary measure*

- **Standards (professional) under development**
  - Rule of irradiation as a phytosanitary treatment for imported fruits
  - Irradiation as a phytosanitary treatment for *Dysmicoccus neobrevipes* Beardsley in banana
  - Minimum Absorbed Dose for the Pytosanitary Irradiation of *Bactrocera dorsalis* in Mango and Litchi
  - Minimum Absorbed Dose for the Pytosanitary Irradiation of *Cydia pomonella*
  - Technical Requirements for Phytosanitary Irradiation of *Bactrocera dorsalis* in Wax-apple and Papaya Fruits
  - Technical Requirements of irradiation treatment for *Grapholitha molesta* Busck

- **Standard Harmonization**
  - *Food Safety Law* of the People’s Republic of China: enforced in June 1, 2009
  - Harmonizing standard related to hygienic, processing, detection, and safety
Facilities

• **Food Irradiation: Gamma and EB**
  – Available Across China
  – Phytosanitary Audit and Accreditation necessary

• **Phytosanitary Irradiation**
  – X-ray Irradiator
    • Built in Tianjin Port in 2011
    • Uses: research, confirmatory tests, and small scale PI
  – Under construction EB: Pingxiang port, Guangxi
Challenges and Prospects

• Challenges for PI Application in China
  – Economic: Cost higher than Fumigation or Hot-water
  – Lack of adapted facilities and procedures
  – Few technical data and standards
  – Public awareness and acceptance gladly

• Enhance research
  – Dose-response Tests
    • Rearing techniques (large number)
    • Testing condition
    • Accurate dosimetry
Challenges and Prospects

- **Confirmatory Tests**
  - Probit 9: fruit flies, mealybugs
  - ED99.99: other insects

- **Guidance & Training**
  - International and National
  - ISPM 18: Research protocol

- **Supports from:**
  - Exporter/importer/enterprise
  - Government
  - International organization
On-going Researches

- **Mealybugs**
  - Jack Beardsley mealybug, *Pseudococcus jackbeardsleyi*
  - Citrus mealybug, *Planococcus lilacinus*
  - *Planococcus minor*

- **Fruit flies**
  - Pumpkin fruit fly, *Bactrocera tau*
  - Guava fruit fly, *B. correcta*

- **Quality test on irradiated fruits**
  - Rambutan, Cherry...

- **Dose detection after irradiation**
Challenges and Prospects

• Technical standard establishment
  – Regulations, procedures and technical standard
  – Products: Fruits → Vegetables → Logs → Grains

• Commercial application
  – Governmental support in policy and funds required
  – Research group as a participant
  – Cooperation of growers, irradiation company, importer/exporter in a profitable enterprise
  – Cooperation with foreign organizations
Commercial application

- Market requires
- Standard
- Facility
- Demonstration

Application of PI in imported fruits
Importing large quantity of tropical fruits from ASEAN countries
Pest intercepted from import fruits

Intercepted Pests (x 10000 times) from ASEAN Countries and Taiwan

<table>
<thead>
<tr>
<th>Year</th>
<th>ASEAN Total</th>
<th>Taiwan Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>0.24</td>
<td>0.05</td>
</tr>
<tr>
<td>2009</td>
<td>1.35</td>
<td>0.25</td>
</tr>
<tr>
<td>2010</td>
<td>6.28</td>
<td>0.32</td>
</tr>
</tbody>
</table>

IRRADIATION FOR LIFE: Safe, Green and Growing
Demonstration Project

Government

Pioneer Application

Research groups

Enterprises
EB Irradiator in Pingxiang Port

- **Destination**
  Pioneer unit for quarantine treatment of fruit imported from Vietnam

- **Facility**
  10 MeV EB. Power: 15 kW
  Nuctech Company Limited

- **Fruits**
  Dragon fruit, Mango, longan, Litchi, Watermelon...

- **Facilities on Ports...**
Thank you for your attention

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